The PyroCb Firepower Threshold: A pyrocumulonimbus prediction tool

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Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

Introduction

- What is the PyroCb Firepower Threshold (*PFT*)?
  - Briggs plume model – foundation of *PFT*
- Need for a *PFT-Flag* – Identify when both plume development and large-hot fires are favoured
  - *PFT* case studies

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What is the *PFT*?

Minimum heat flux (firepower) required for pyroCb to form.

- Varies with the atmospheric environment

1. Insufficient firepower
2. Sufficient firepower

Inglewood Fire, 5 Dec 2016: Nick McCarthy

Briggs Plume Model

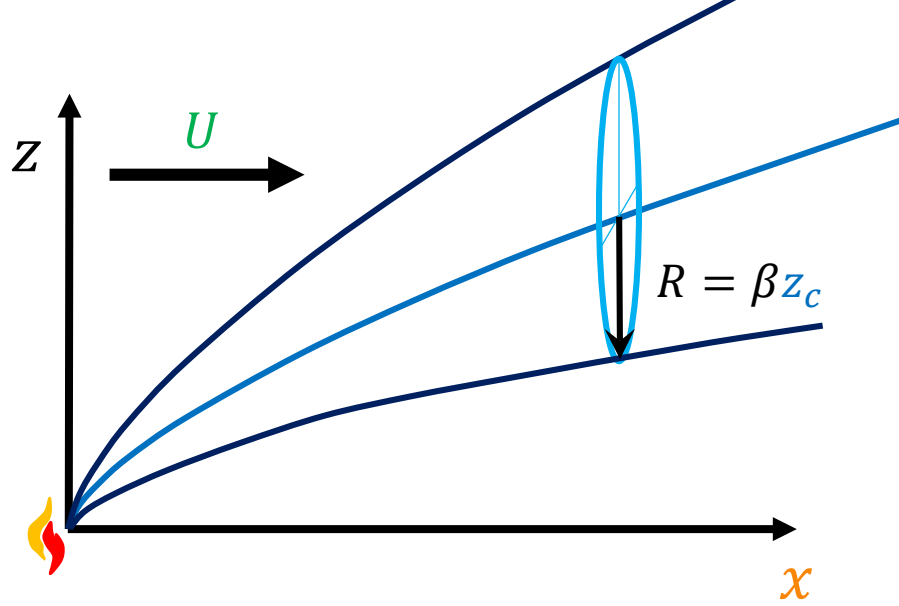
- $z_c = \left[\left(\frac{3}{2\beta^2}\right)\frac{B_{flux}}{\pi}\right]^{\frac{1}{3}} \frac{x^{\frac{2}{3}}}{U}$

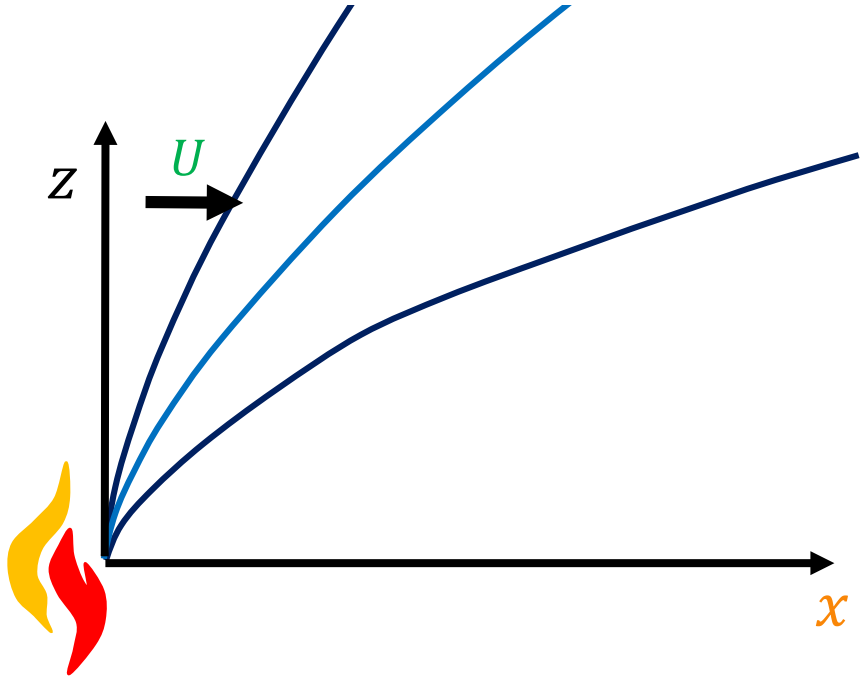
To double the plume height:

Increase firepower by ***8*** times

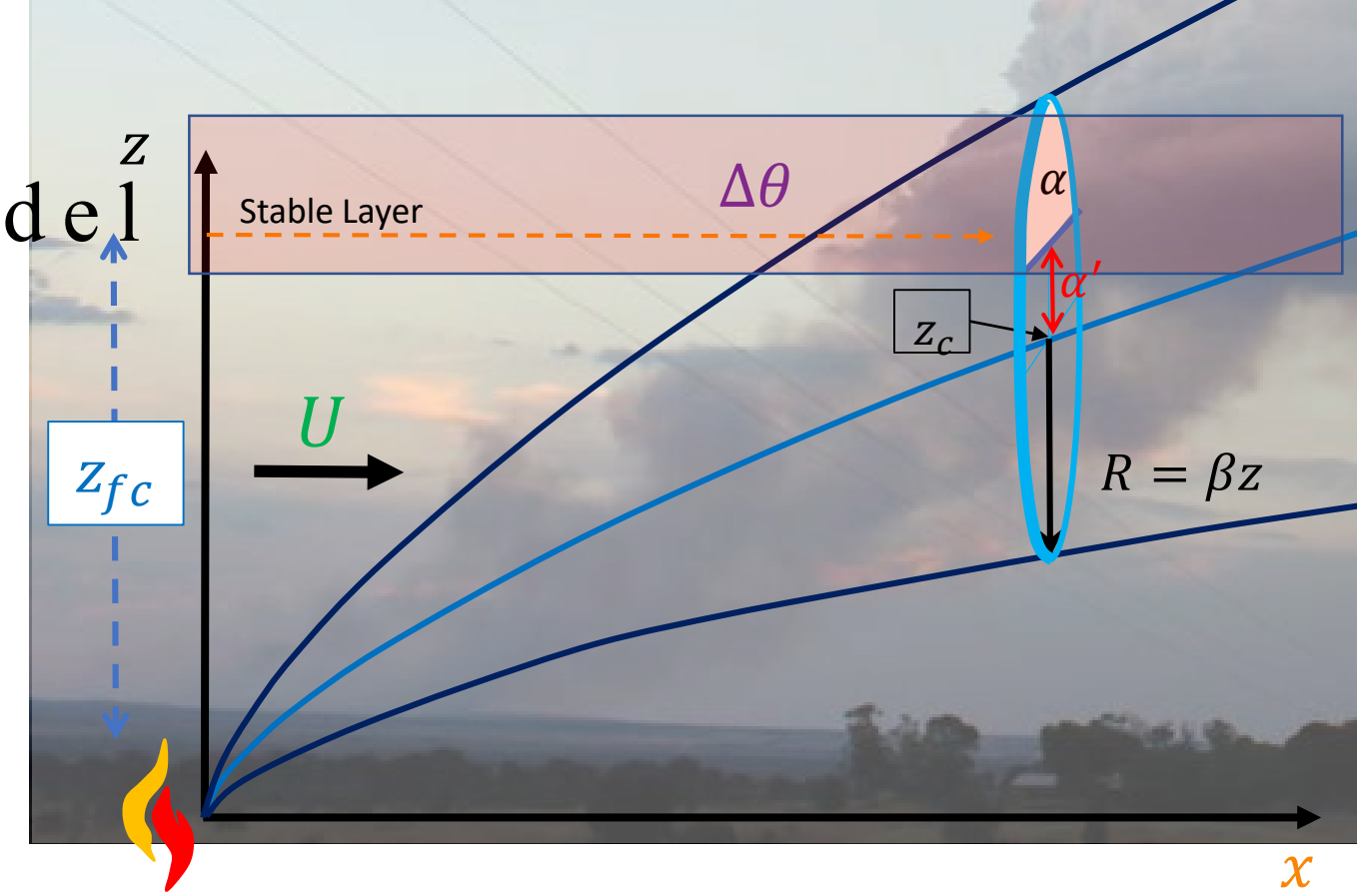
Or

Halve the wind speed





Use Briggs Plume Model



An equation for the buoyancy distribution within a Briggs plume is inverted:

- $PFT = \left[\pi \rho C_p g \left(\frac{\beta'}{(1+\alpha')\beta'}\right)^2\right] (z_{fc})^2 U \Delta\theta$ ~ Constant

- z_{fc} : The larger z_{fc} the higher the plume must rise (more firepower required).
- U : The stronger U the more firepower required to counter the plumes tendency to bend over.
- $\Delta\theta$: A larger capping inversion requires a hotter plume and thus more firepower.

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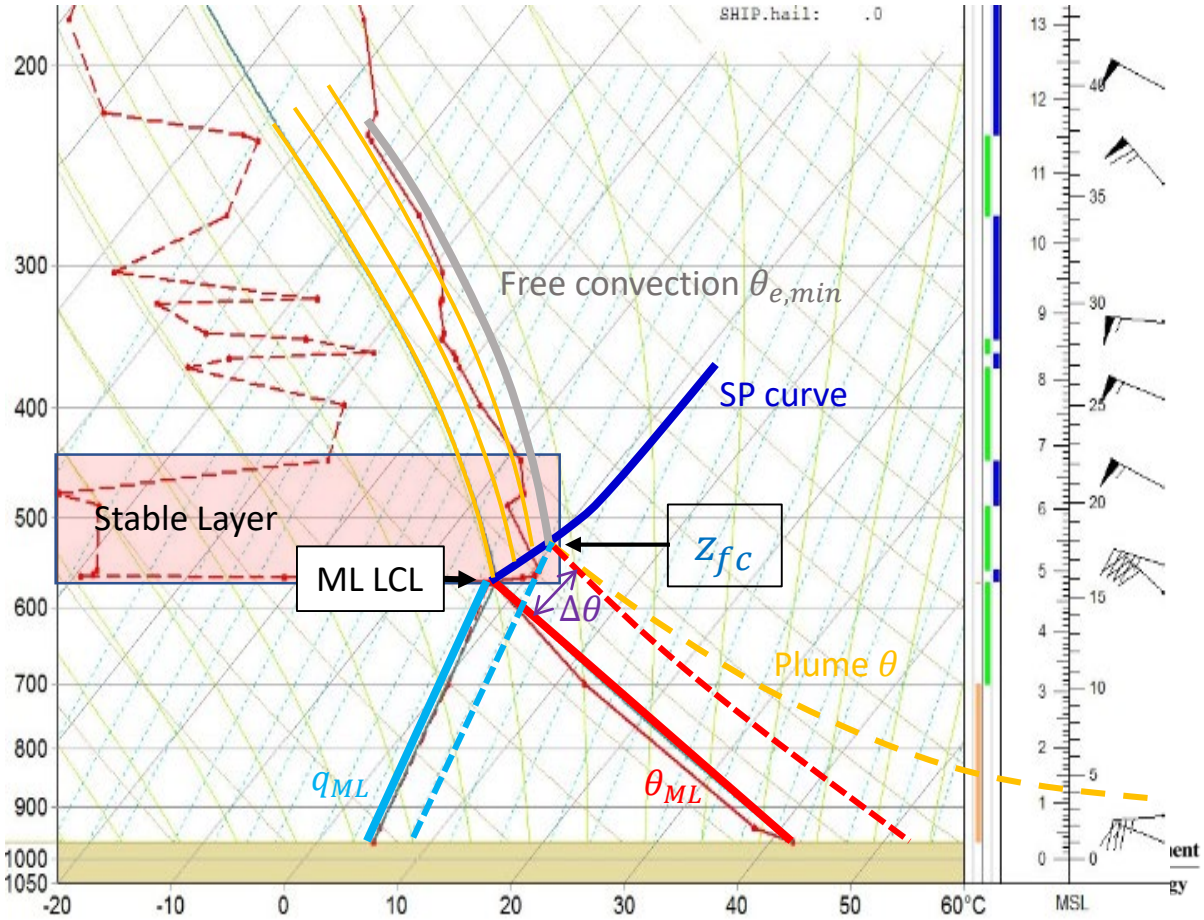
PFT Ingredients

- Use pyroCu thermodynamic model to determine *PFT* ingredients.
  - $PFT = C(z_{fc})^2 U \Delta\theta$



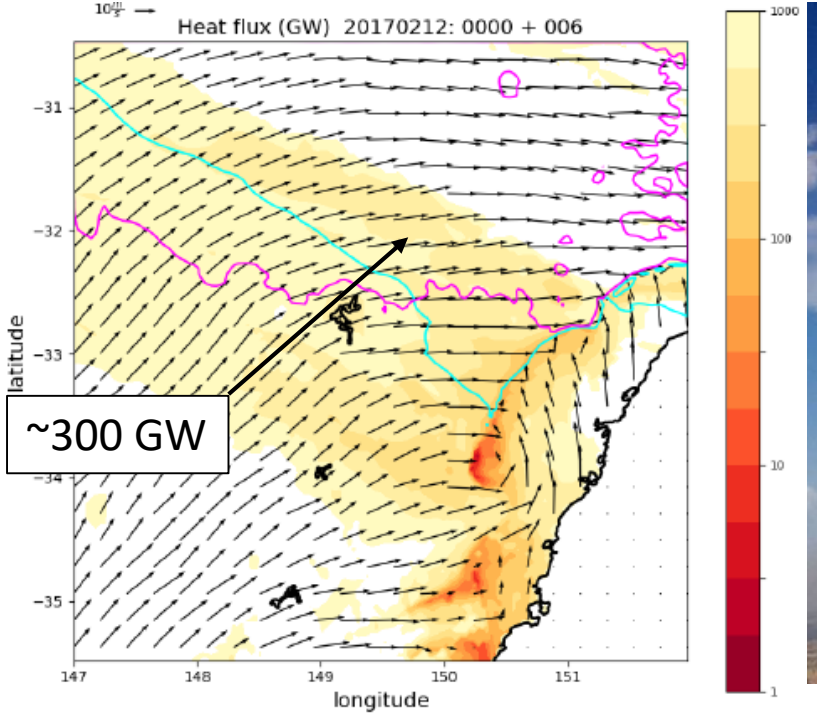
Using the PFT

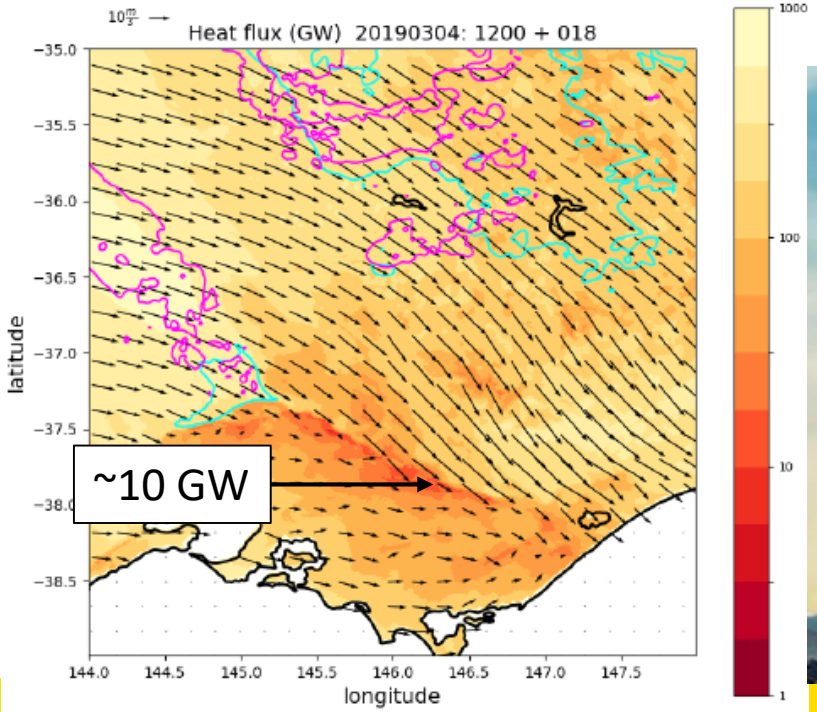
Substantial *PFT* differences between events.

Vastly different "threat" values?

PyroCb conditions at Sir Ivan were much less favourable than Licola.

However, Sir Ivan had extreme fire conditions, potentially much hotter fire.





Using the PFT

Late April:

Cool Autumn conditions – *PFT* very favourable

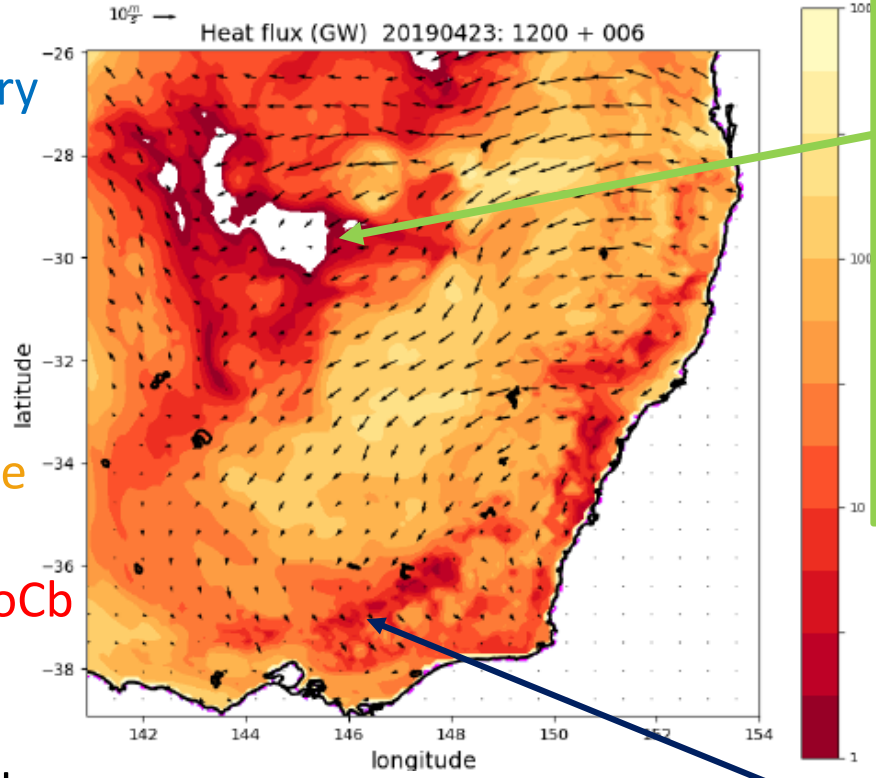
- Bourke – *PFT* ~ 1 GW
- Mt. Buller – *PFT* ~ 5 GW

Large-hot fires virtually impossible

Conditions that highly favour pyroCb *do not* favour intense fires

Need to incorporate fire potential,
- Within the diagnostic, or
- Separate to the diagnostic

Experimenting with a "PFT flag"
– Alerts users when to examine *PFT*.

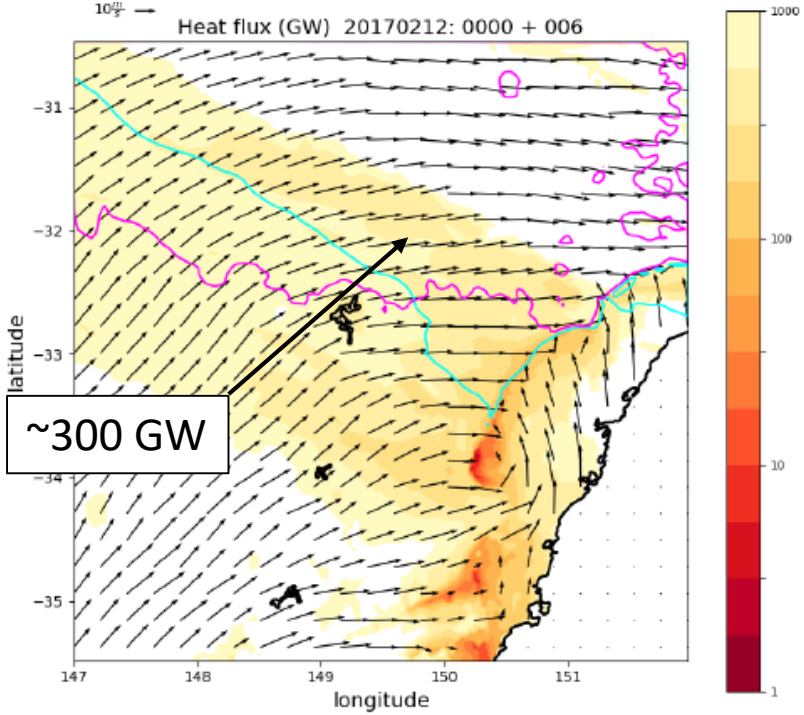


Darling River after 75 mm rain

Mt. Buller

Using the PFT

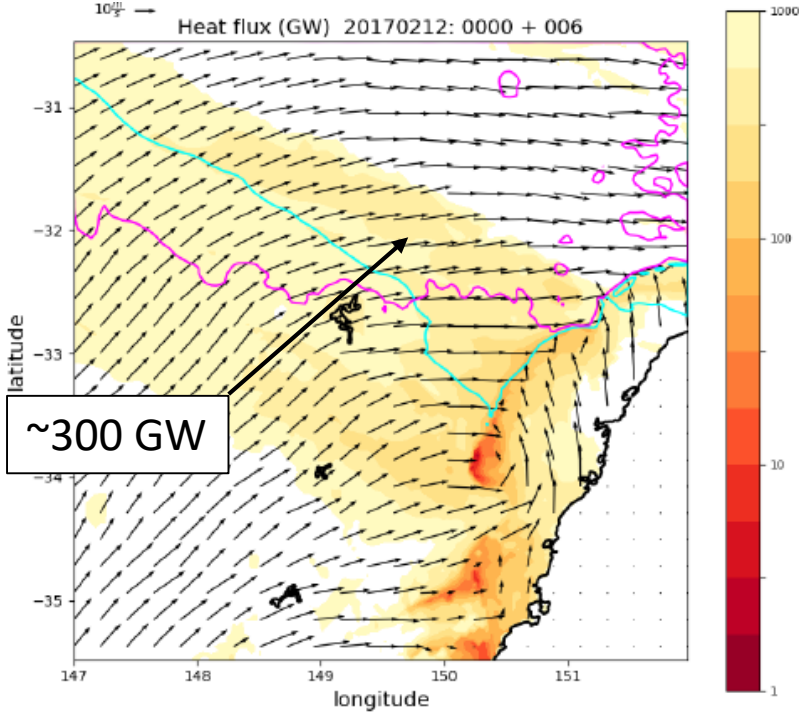
PFT flag: Sir Ivan

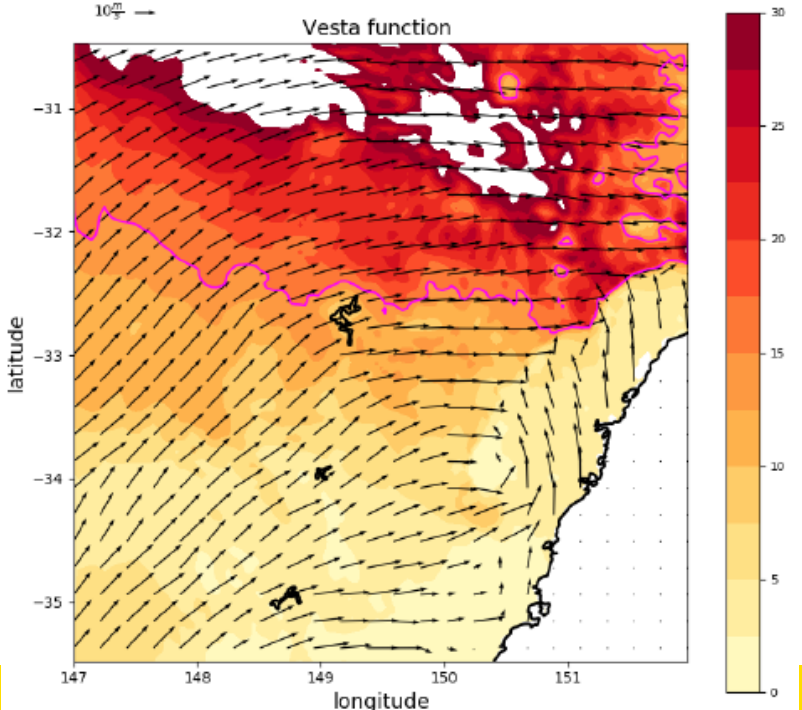


Using the PFT

PFT flag: Sir Ivan

Very strong winds, Hot and Dry
- Extreme fire danger (Vesta)

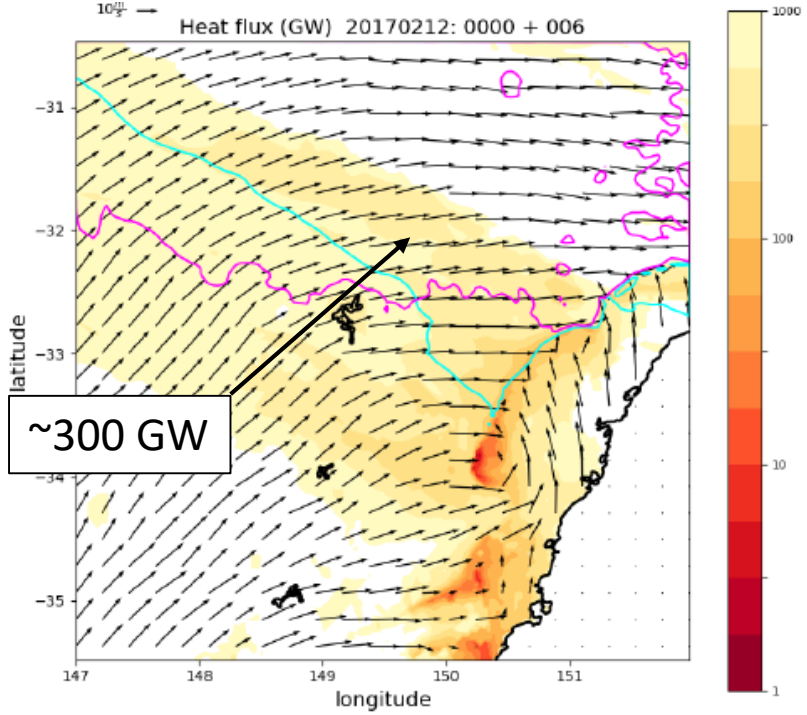


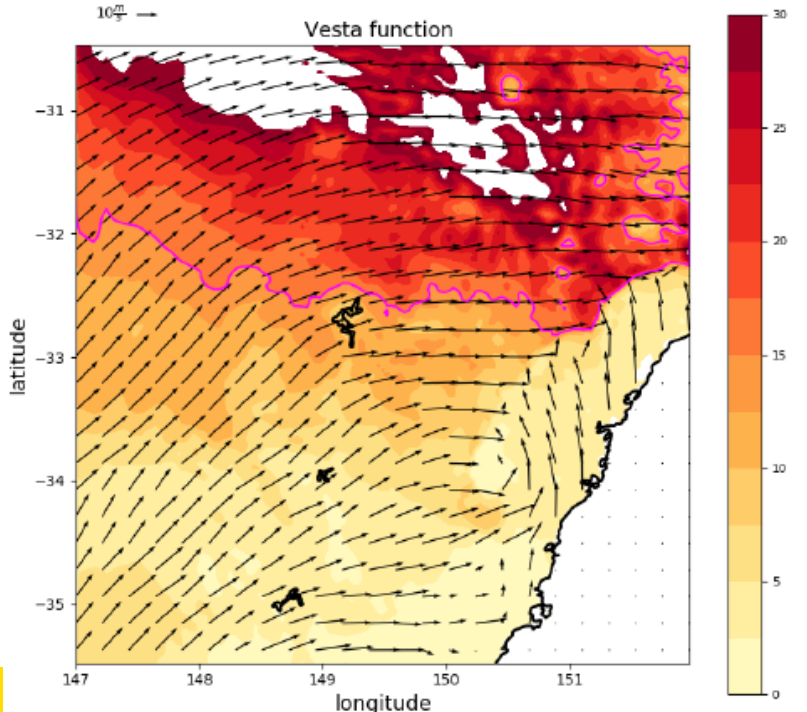


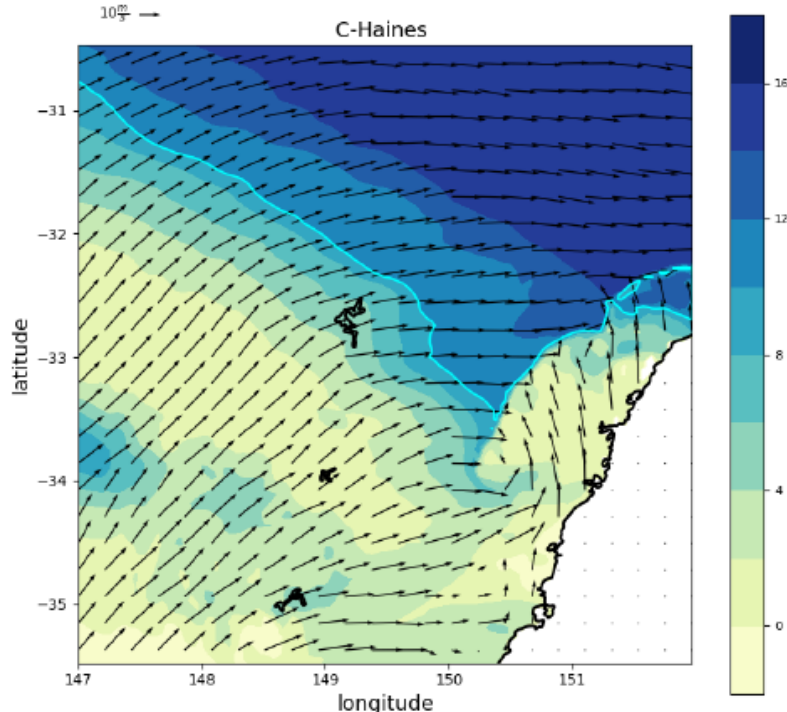
Using the PFT

PFT flag: Sir Ivan

Very strong winds, Hot and Dry
- Extreme fire danger (Vesta)
- C-Haines > 10 (was > 14)





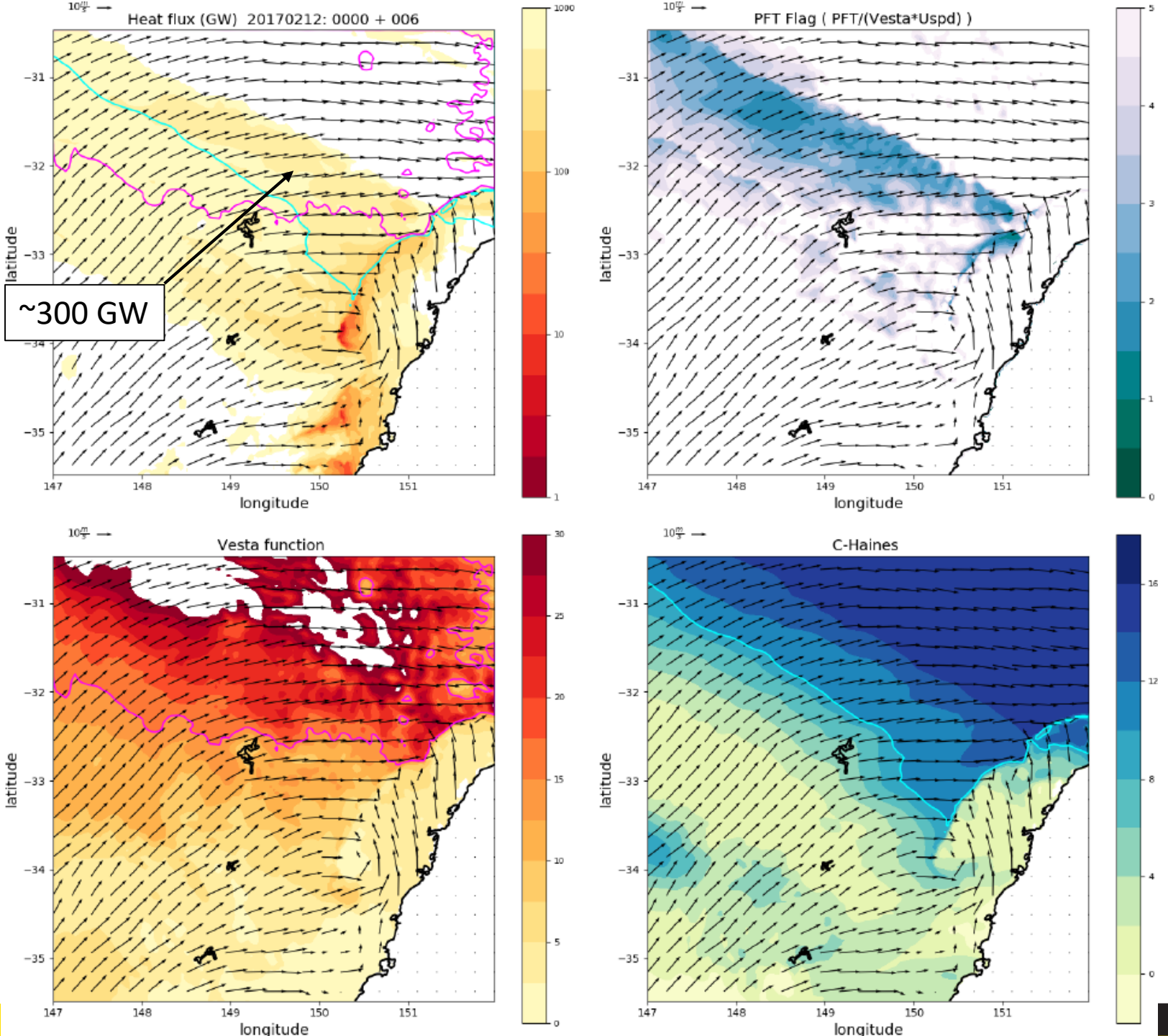


Using the PFT

PFT flag: Sir Ivan

Very strong winds, Hot and Dry
- Extreme fire danger (Vesta)
- C-Haines > 10 (was > 14)

PFT flag = *PFT*/(Vesta×windspeed)
- Flag "triggered" on wind change
- Coincides with observed pyroCb

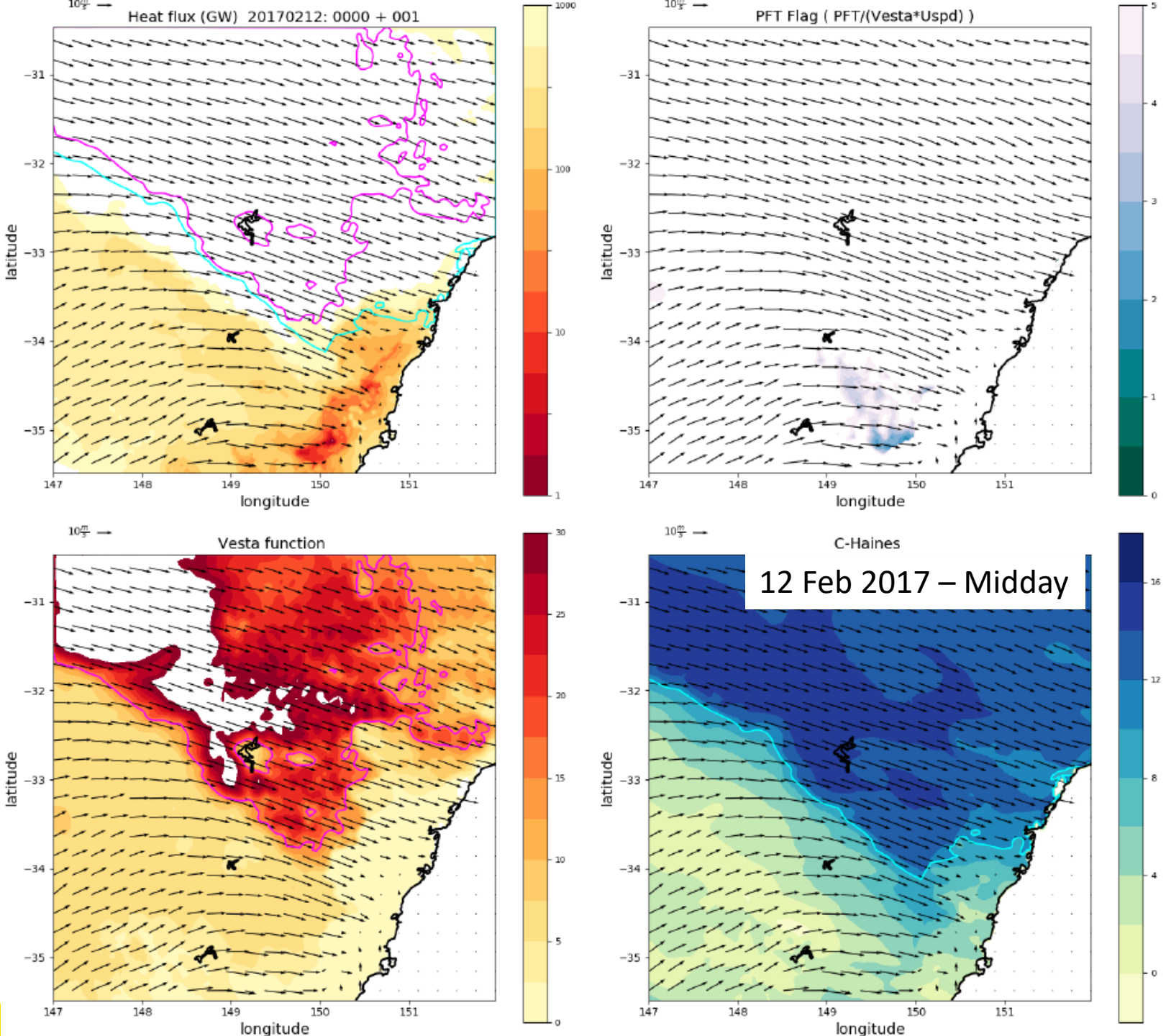


Using the PFT

PFT flag: Sir Ivan

5 Hours Earlier

- *PFT* > 1000 GW (off the scale)
- Vesta extreme
- C-Haines > 14
- PFT flag *not* triggered

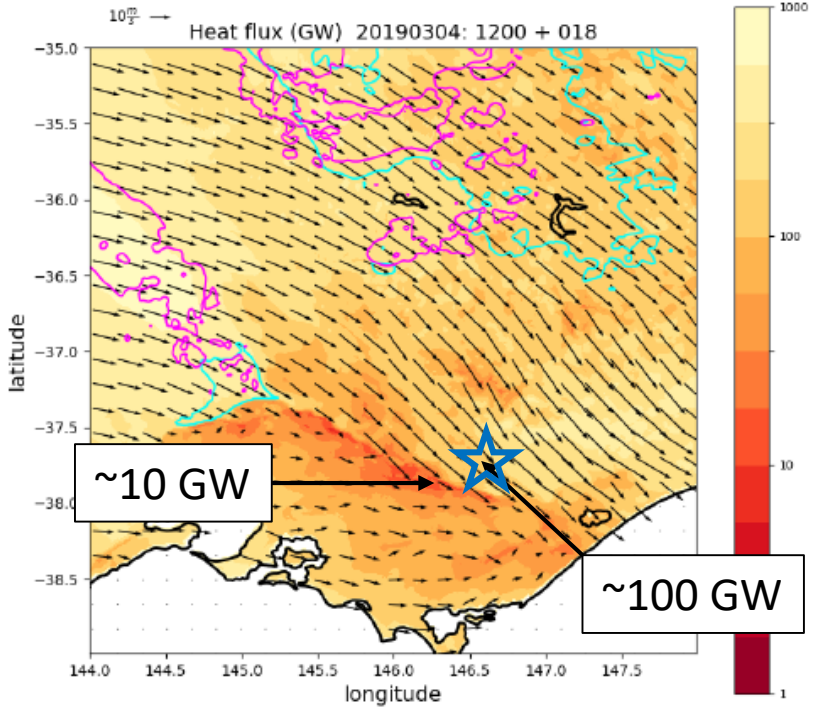


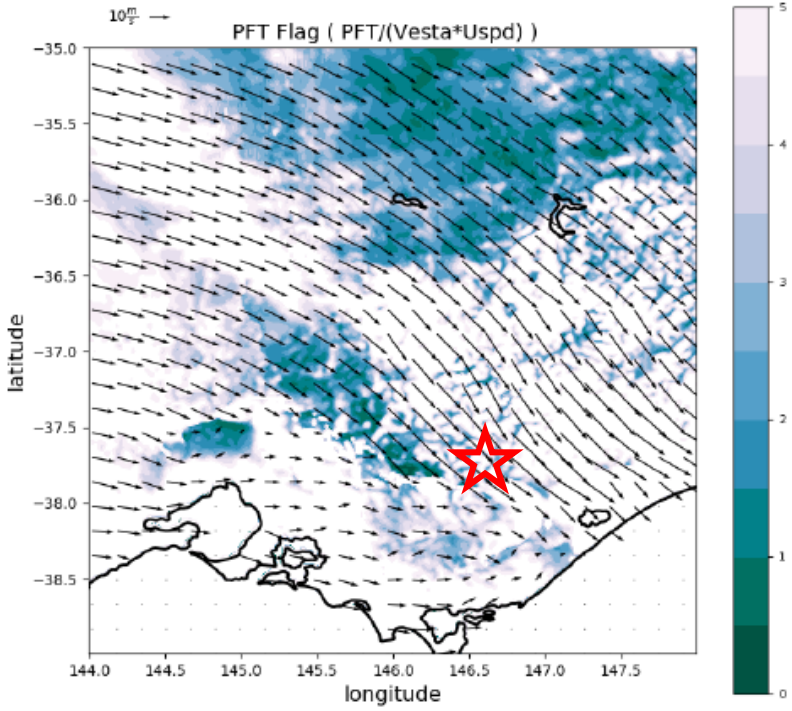
Licola

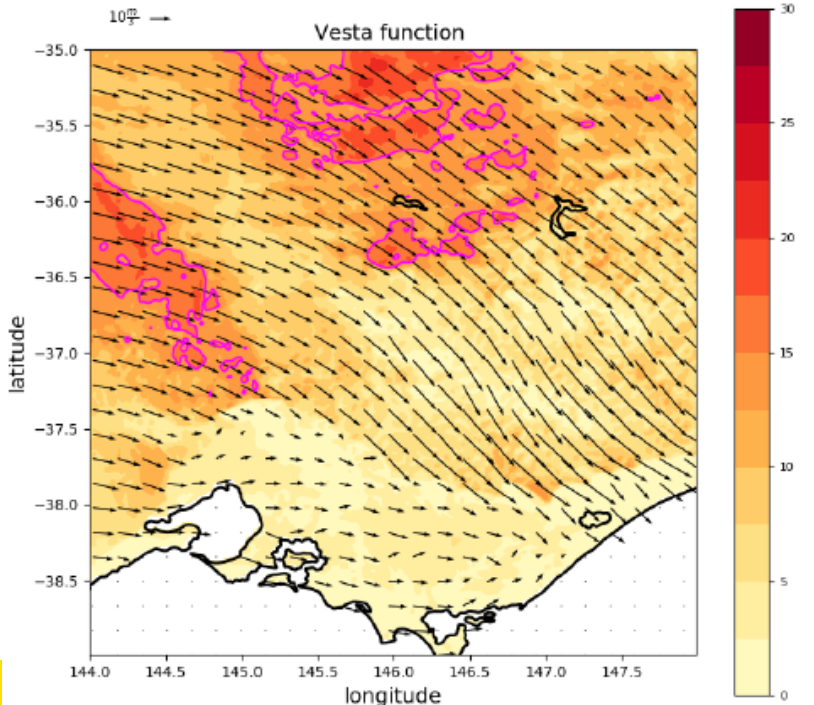
- 5 March 2019

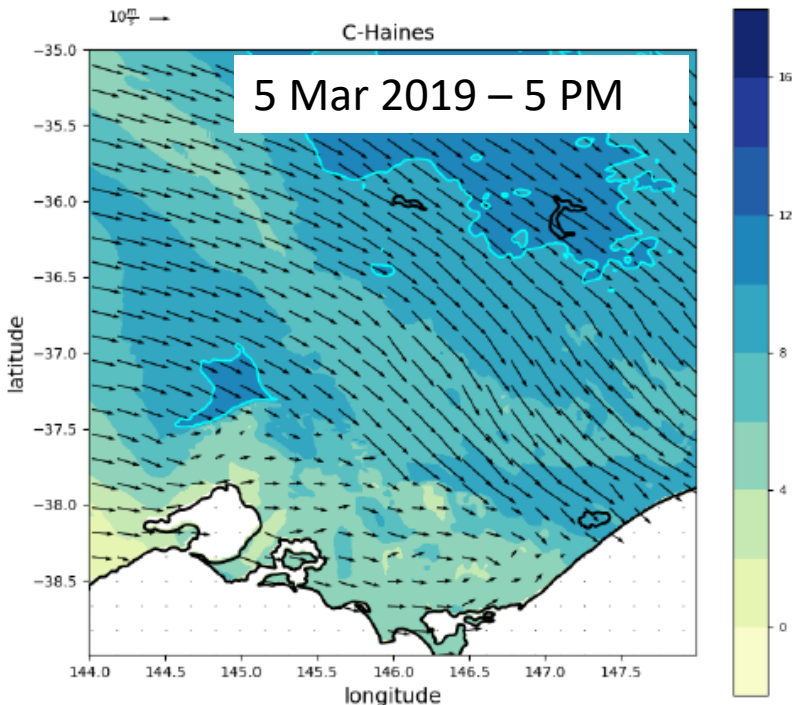
Strong winds, Hot and Dry
- High fire danger
- C-Haines < 10 all day

PFT suggests: *PyroCb highly favourable on the wind change*





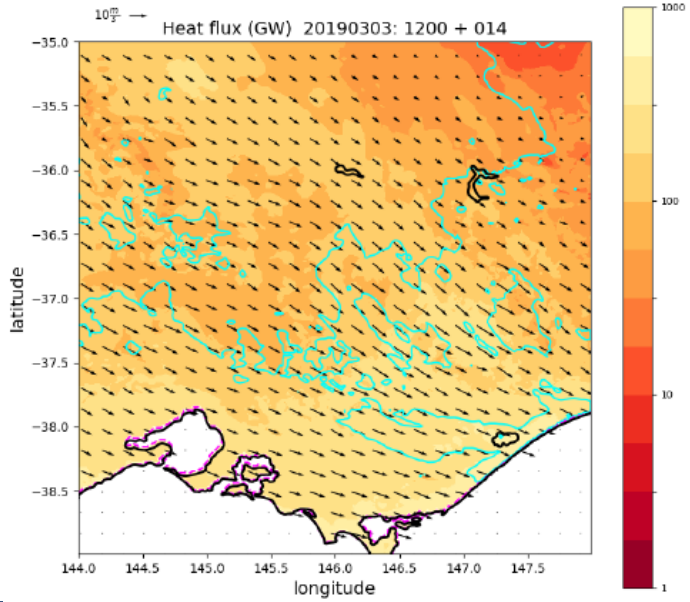


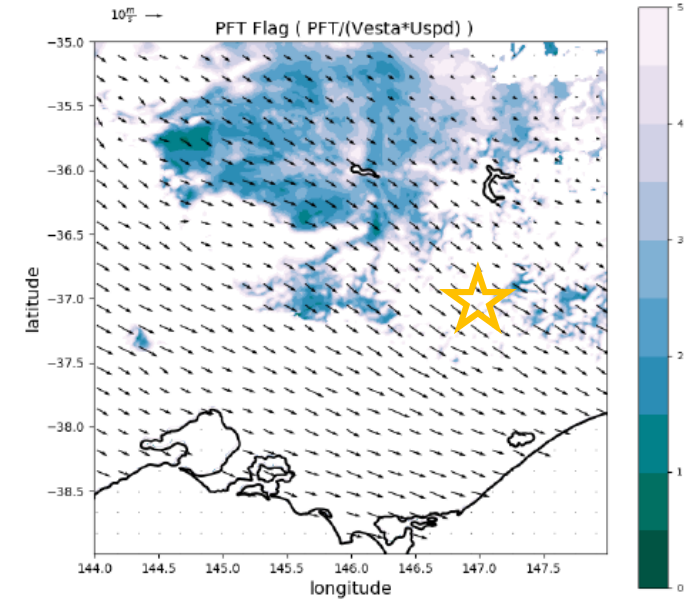


Mt Hotham

Day before Licola (previous case) - 4 March 2019

PFT analysis 1300, Photos 12:00 – 13:00



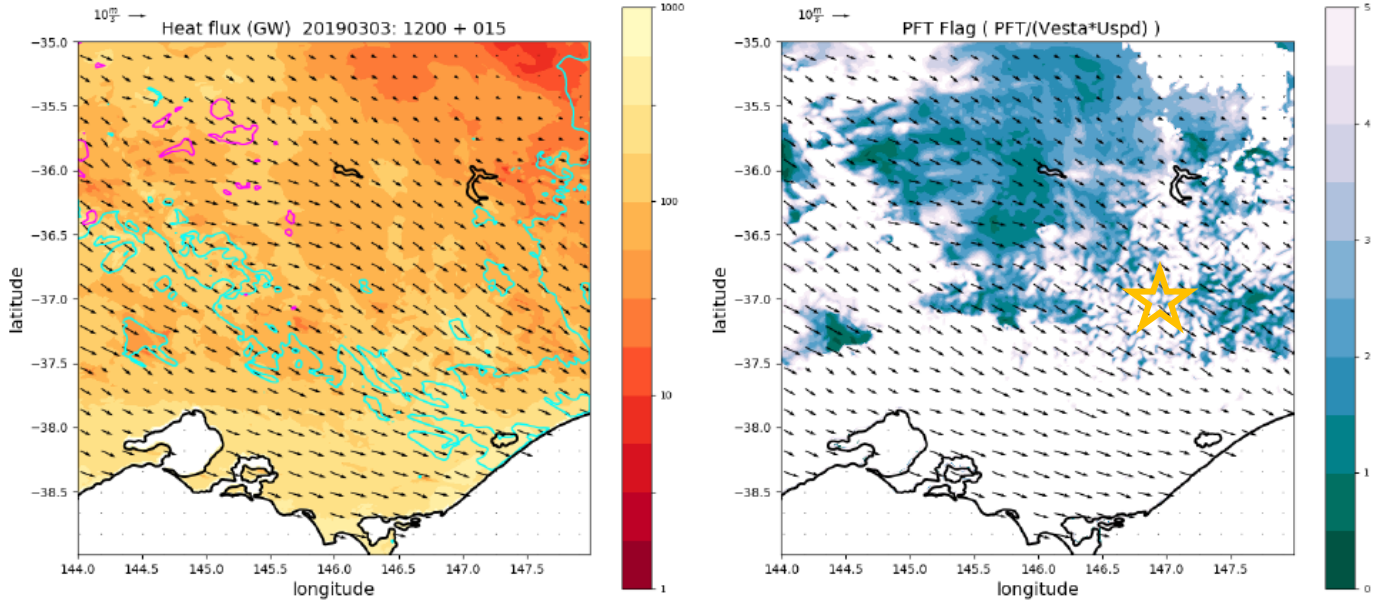


Mayford-Tuckalong Track fire (nearby)
Mount Darling-Cynthia Range Track fire (distant)

Mt Hotham

Day before Licola (previous case) - 4 March 2019

PFT analysis 1400, Photos 13:00 – 14:00

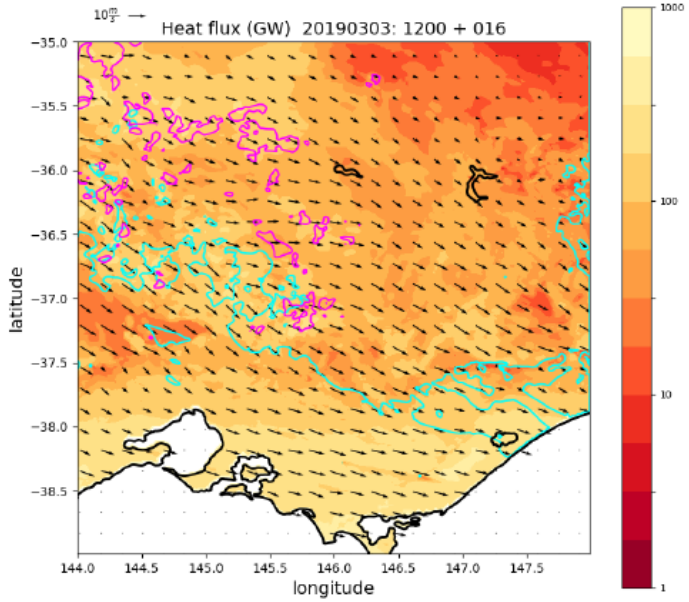


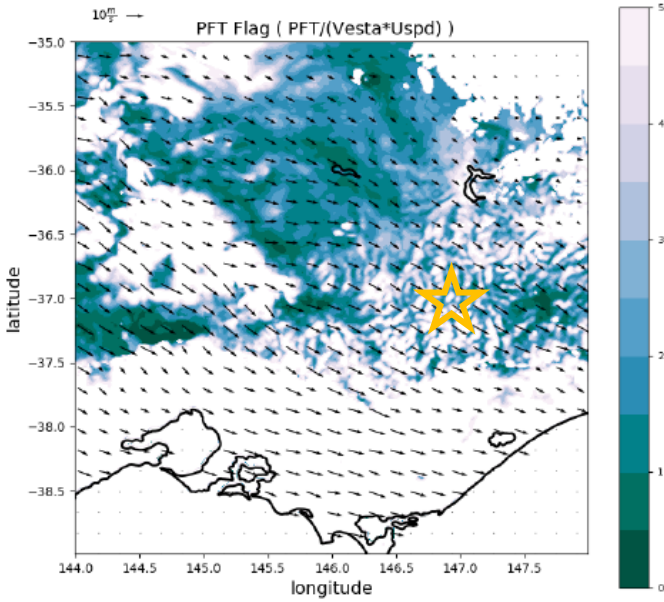
Mayford-Tuckalong Track fire (nearby)
Mount Darling-Cynthia Range Track fire (distant)

Mt Hotham

Day before Licola (previous case) - 4 March 2019

PFT analysis 1500, Photos 14:00 – 15:00



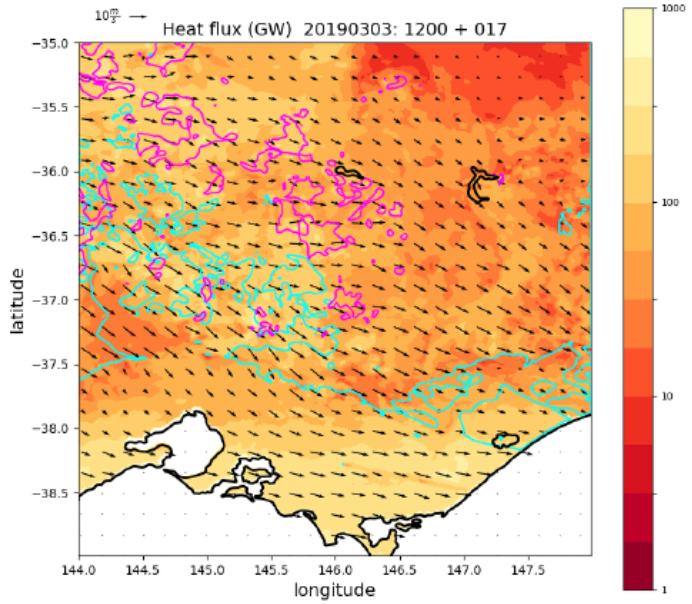


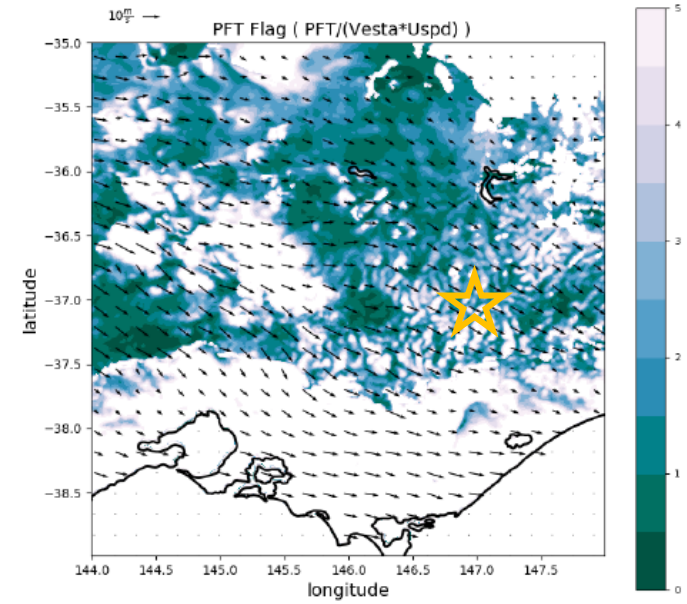
Mayford-Tuckalong Track fire (nearby)
Mount Darling-Cynthia Range Track fire (distant)

Mt Hotham

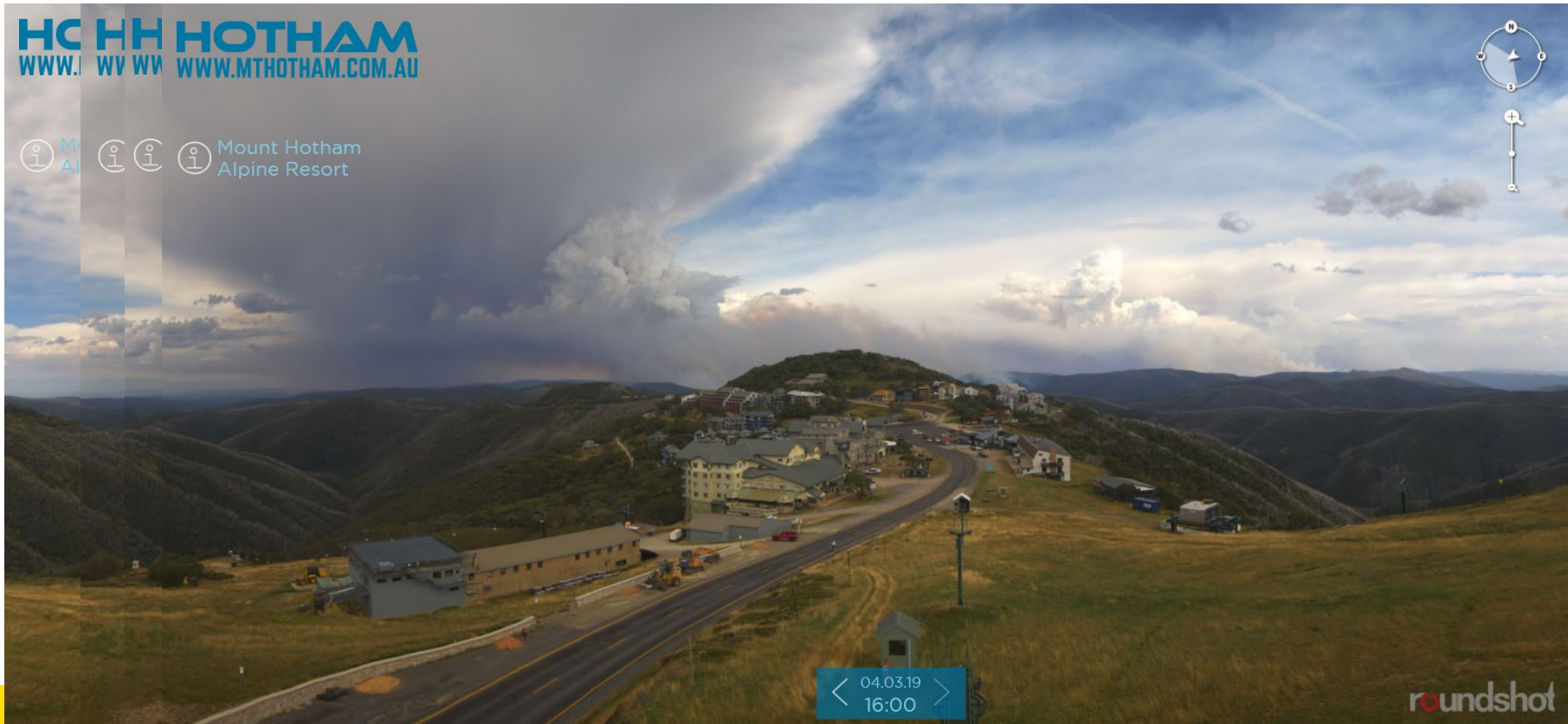
Day before Licola (previous case) - 4 March 2019

PFT analysis 1600, Photos 15:00 – 16:00





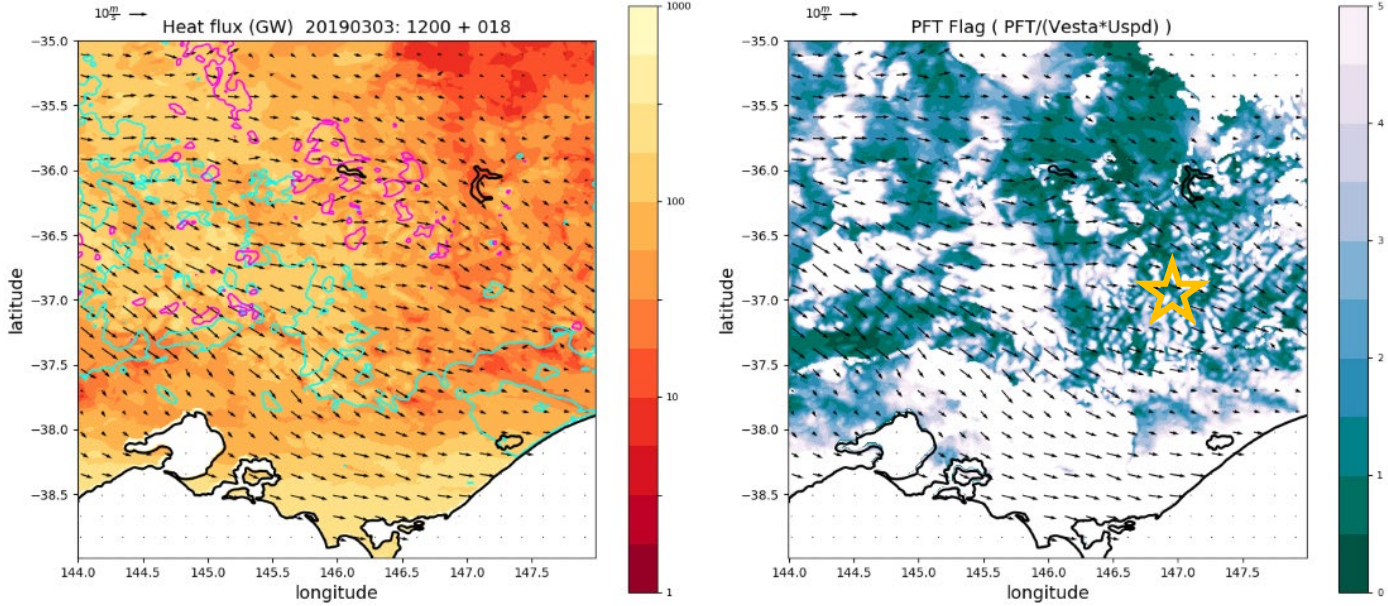
Mayford-Tuckalong Track fire (nearby)
Mount Darling-Cynthia Range Track fire (distant)

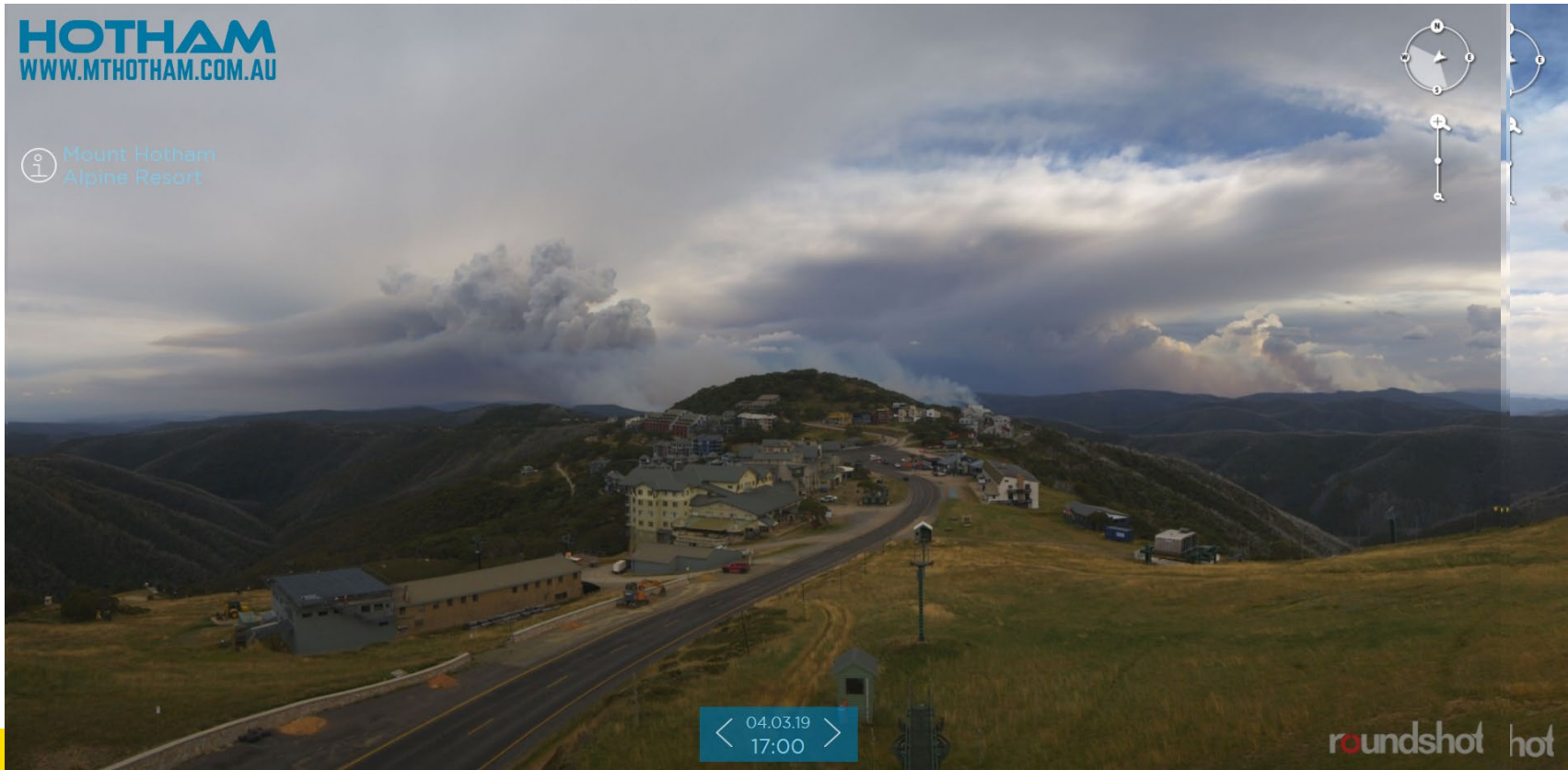


Mt Hotham

Day before Licola (previous case) - 4 March 2019

PFT analysis 1700, Photos 16:00 – 17:00

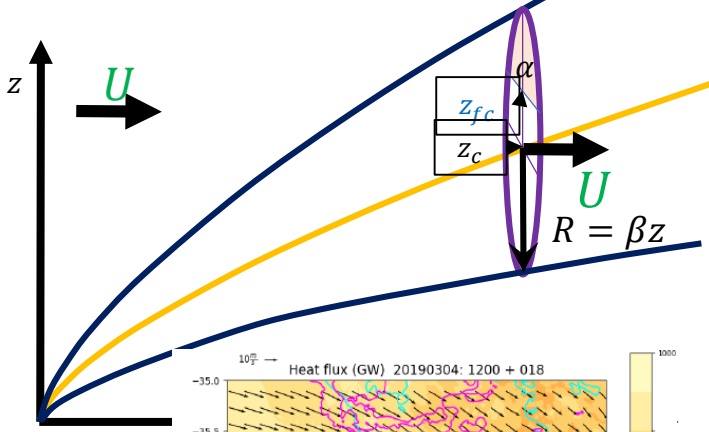




Mayford-Tuckalong Track fire (nearby)
Mount Darling-Cynthia Range Track fire (distant)

Summary

- $PFT = C(z_{fc})^2 U b_{fc}$



- Use Briggs model to determine PyroCb Firepower Threshold (*PFT*)
- Plot *PFT* spatial maps to determine pyroCb favourability
- *PFT* varies by many orders of magnitude - Conditions that highly favour pyroCb *do not* favour intense fires
- Use PFT flag to identify pyroCb threat
- Applied to 30+ cases – looking very promising